

# Study of the Information Diffusion in the Customer Decision-making Process Based on the Field Theory

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## Abstract

In this paper, we abstract a three-dimensional coordinate from the factors which influence information diffusion among customers, construct the information diffusion field, and combine the features of the social network to solve two basic problems in the customer decision-making process: one is what the conditions that make the information diffusion operate are, the other one is what the rule of information diffusion is. With the changing level of consumers' acceptance to the information, we simulate the diffusion process in social network, and draw the conclusion that the information diffusion field can describe the information diffusion process suitably.

## Keywords

*Information Diffusion; Field; Customer Decision; Social Network*

## Introduction

Making consumer decision is a procedure of processing and disposing information. In this procedure, industries publicize the products' information through many ways. Consumers deliver the information to other consumers. The information is used to affect the individuals' final decision. The process of information diffusion satisfies the features of the "field": firstly, it has a specific physical space; secondly, there are several elements in the space; thirdly, each element has its specific rules of distribution and movement which are connected with each other and are influenced by each other. Through this research of diffusion process, the key node and main factor between consumers can be revealed.

According to the existing research, the study about information diffusion which is based on the "field" is focused on the analysis of qualitative description and the models of diffusion state. Absolutely, we can't get quantitative results through the existing experiment.

Based on the social network which is composed with consumers, this paper constructs an information diffusion field with the theory of "field" from physics, discusses the conditions and diffusion rules of information diffusion, uses Matlab software to simulate experiment. It shows that the method based on the field theory can be used for describing the process of information diffusion in the process of making consumer decisions. And it provides a feasible method for the study of information diffusion.

## The Constitution Of Information Diffusion Field

The diffusion of information between consumers mainly depends on interpersonal relationship, namely the process of information transfer is realized by the communication between individuals. The information diffusion between consumers will be increasing as the time passes. It is based on the consumers who take part in the behavior of diffusion. At the same time, it depends on the social network and information gap between consumers. The information diffusion is a complicated process, and it involves many factors which are mainly composed by the information source, the information sink, the information, the network and the noise. The information source here means the consumer who has more information, and is also called the information source consumer. The information sink here means the consumer who has a little or little information, and is also called the information sink consumer. The information here means the product information which is gained by consumers, and it can be measured by the information amount of Shannon. The network in this paper means the social network in which the consumers'

information can be diffused. And the social network shows the relationship between consumers. When the consumers are related more closely, the efficiency of information diffusion is better. The noise in the process of information diffusion appears as the interference from media decides the efficiency of information transfer.

The process of information spread can be defined from two aspects: one is the network structure of information diffusion; the other one is the rules of information diffusion. By constructing the information diffusion field while consumers make decision, we describe the network structure of information diffusion. We describe the process of information diffusion through the gravity and strength in the information diffusion field.

#### Construct The Information Diffusion Field In The Consumer Decision

Many scholars apply the "field" theory into social science, and study various problems with the three dimensional space "field" which is based on the characteristics of the respective fields. Zheng Xifu agrees that everyone has a psychological field, including the natural factors, the social factors and the individual factors. Using the common type in the coordinates of orthogonal surface, this paper abstracts the factors which affect the information diffusion between consumers as the social distance, the psychological distance and the media efficiency to construct an information diffusion field.

#### *Establish the X Axis in the Information Diffusion Field*

X axis describes the endogenous factors which influence the information diffusion between consumers. Psychological distance reflects the psychological sense of identity. It is the internal foundation of building the imparting relationship. If the psychological distance is smaller, the users will be more willing to share the information. The cognition, the emotion and the attitude are the main aspects which influence psychological distance. Using the consumer's cognitive ability ( $x_1$ ), emotional state ( $x_2$ ) and focusing degree ( $x_3$ ) to describe the psychological distance ( $x$ ) between the information source consumer and the information sink consumer during the process of spreading information:

$$x\% = f(x_1, x_2, x_3) = \alpha_1 x_1 + \alpha_2 x_2 + \alpha_3 x_3$$

#### *Establish the Y Axis in the Information Diffusion Field*

Y axis describes the exogenous factors which influence the information diffusion between consumers, and it can also be described as the community distance. Consumers who have similar social status, culture level and living environment have shorter social distance and focus on more similar informational type.

Consider consumers' social status ( $y_1$ ), cultural level ( $y_2$ ) and living environment ( $y_3$ ) as the main factors which influence the social distance ( $y$ ) between consumers. And the social distance can be expressed as:

$$y\% = f(y_1, y_2, y_3) = \beta_1 y_1 + \beta_2 y_2 + \beta_3 y_3$$

#### *Establish the Z Axis in the Information Diffusion Field*

Z axis describes the information transferring efficiency through different medium. Different medium makes the content, legibility and authenticity different which directly influence the efficiency of the information diffusion.

#### Analysis Of The Information Diffusion Process In The Field

##### *The Conditions of Information Diffusion*

Consumers' information diffusion process is embedded in the social network. Information can be transferred only when there is a one-way or two-way interpersonal relationship network. In the one-way interpersonal relationship network, the diffusion efficiency has a direct connection with the social position and the influence of information source consumers: the higher social status and the greater social influence of information source consumer mean the information diffusion efficiency is higher. In the two-way interpersonal relationship network, the diffusion efficiency has a direct connection with the relationship between two sides: if the members' relation is tighter, the willing of informational diffusion will be stronger and the diffusion efficiency will be higher.

In the information diffusion field, consumers are in a particular position, namely a three dimensional space vector. We describe the degree of intimacy and strength of impact by measuring the vector distance. Use  $P_i(x_i, y_i, z_i)$  to represent the information source customer and  $P_j(x_j, y_j, z_j)$  to represent the information

sink customer. Euclidean distance can be used to describe the distance of information transfer between customer  $P_i$  and customer  $P_j$ .

Another necessary condition of information diffusion is the existence of informational gap, namely informational potential difference. Informational potential difference means the difference of the amount of information between the information source customer and the information sink customer. Consumer's informational amount is different. The consumers who have more information delivered to the consumers who have less information. In this way, the informational potential difference is formed. So this difference is mainly embodied in the amount of information.

$H_i$  represents the amount of information from the information source customer  $P_i(x_i, y_i, z_i)$ , and  $H_j$  represent the amount of information from the information sink customer  $P_j(x_j, y_j, z_j)$ . According to Shannon's entropy principle of information, consumer  $P_i$  is the amount of information. The potential difference between the information source consumer  $P_i$  and the information sink consumer  $P_j$  can be calculated by the difference of informational amount:

$$\Delta H = H_i - H_j$$

When  $\Delta H \leq 0$ , information can't spread.  $\Delta H$  can't be infinite, either. If the gap of information is too wide, the promotion and communication can't go on, the credibility of the information itself will be questioned, and the information sink consumer may be negative because of the suspicion. In this case, negative information will be spreading, and it will negatively impact consumers' decision. So only when potential difference of information is in a certain range, information can be spread positively.

### *The Rules of Information Diffusion*

An information source consumer may be connected with many information sink consumers. But the information source consumer should spread information in a certain sequence which is decided by the field force. Field force shows the dynamic of information diffusion. According to the Coulomb's theory, the dynamic of information diffusion can be represented as:

$$F_{ij} = k(H_i H_j) / (r_{ij}^2)$$

$F_{ij}$  means the dynamic of information diffusion from the information source consumer  $P_i$  to the information sink consumer  $P_j$ , and  $k$  means the proportional

coefficient which shows the spreading willing of the information source consumer and the receiving willing of the information sink consumer.

The formula shows that the field force from the same consumer to the different consumers is different. The field force is inversely proportional to the square of the distance between both sides. In fact, it is the relationship and the media efficiency that will affect the efficiency of information transfer.

Gradient describes the direction of the largest rate of information increasing. We can reduce the gravity gradient function in the information diffusion field.

The distribution of each factor in the information diffusion field is different. Their functioning ways, forms and gradients are different. The information diffusion process between consumers follows the gradient diffusion rule, namely the information spreads to the direction where the gravitation is the biggest and the gradient is the least.

### *The Study of Information Diffusion in the Social Network*

The information diffusion in the social network meets the following assumptions: (1) in the process of information dissemination, only one kind of information is spreading; (2) information only can spread from the information source consumer to the information sink consumer, and each pair of consumers can transfer the information only once; (3) the social network is closed, the members can't deliver information by self-study, and the members can only obtain the information from other individuals, namely can only obtain the information through the promotion from mass media and oral communication. As the small world network has higher gathered coefficients and smaller average distance, this paper describes the social network by constructing a small world network. The information spreads along the direction where the gradient and the gravity are both maximum. And the specific process is shown as follows.

Step 1: construct a small world network by  $N$  consumers.

Step 2: suppose  $P_i$  is the information source consumer whose information content is  $H_i$ . Suppose  $P_j$  ( $1 \leq j \leq N-2$ ) is the information sink consumer who has interpersonal relationship with  $P_i$ , and the information content is  $H_j$ .  $P_i \in D$  (diffusion source) represents the set of the information source consumers.

Step 3: calculate the information potential difference  $\Delta H = H_i - H_j$ . If the information potential difference is in a certain range, perform the next step. If not, go back to step 2 to judge the next point which is connected with  $P_i$ .

Step 4: choose the information sink consumer  $P_k$  who first accepts information from the information source consumer  $P_i$  in  $P_j$ . The condition is  $F_{ik} = \max(F_{ij})$  and  $\nabla F_{ik} = \min_{j \in J}(\nabla F_{ij})$  ( $1 \leq j \leq N$ ).

Step 5: the information source consumer is  $P_k$ . The process of adjusting private information is  $H_k' = H_k + \omega H_i$ . ( $\omega$  represents the accepting level of information sink consumer  $P_j$ , and  $0 \leq \omega \leq 1$ )

Step 6: to make the  $k$ th consumer to take part in the next process of information diffusion, and to determine if  $P_i$  will continue spreading.

Step 7: traverse all  $P_j$  and  $P_j$  until DS is empty. The iteration finishes.

### Experimental Analysis Of The Information Diffusion Process

The information diffusion process is a complicated social system evolution process, which is based on the social network. We use matlab to build information diffusion field and to analog the diffusion process of information diffusion.

#### The Preparation

The position of each consumer in the information diffusion field is determined by corresponding coordinate  $(x, y, z)$ . (Assuming all  $x_1, x_2, x_3, y_1, y_2, y_3, z$  obey the normal distribution of  $N(0.5, 0.1)$ ). Assume there is only one source of information. The consumer of  $N=1$  is the information source, and its information amount is the largest (His/Her understanding degree to some product is 99.99%,  $H_{\max} = \log(1/(1-0.9999)) = 13.29\text{bit}$ ). And assume other consumers only have a little information. So we suppose that it follows the Normal distribution and the range of information potential difference is  $0.8 H_{\max} < H < 0.1 H_{\max}$ .

Contrast a small world network whose dimension is three and rewiring probability is 0.5. Each node in this network represents a consumer. The edges between the nodes reflect whether there are connections between nodes, and the lengths of the paths reflect the distance between two consumers.

### The Results of the Experiment

Information spreads along the direction of the biggest gravity and smallest gradient. As time passes, the informational amount increases. In this case, we get different parameters from the different accepting levels. Along with the increase of iteration times, the amount of information changes (Fig. 1) and the number of the consumer who is accepting information changes (Fig. 2).

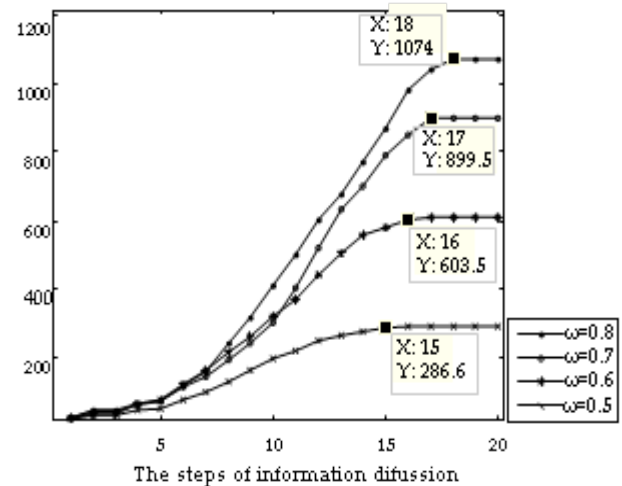


FIG. 1 THE AMOUNT OF INFORMATION IN THE SOCIAL NETWORK

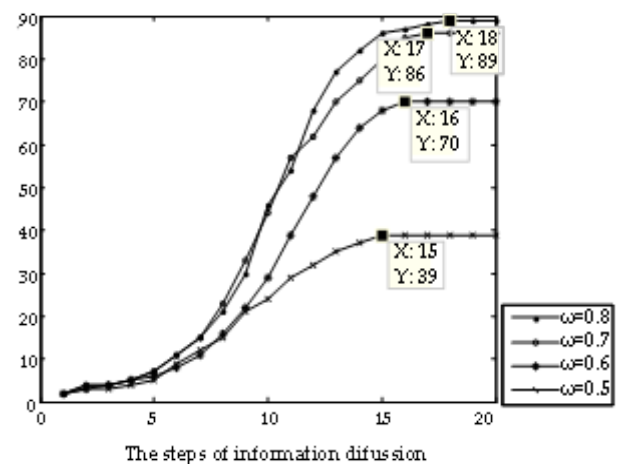


FIG. 2 THE NUMBER OF THE CONSUMERS WHO ARE ACCEPTING INFORMATION IN THE SOCIAL NETWORK

According to the analysis of the two figures above, we can study the result of information diffusion (as TABLE 1 shows) when the average degree of receiving information is different. Along with the average level of accepting information rising, the total amount of information and the number of consumers who can accept information show the increasing trend. The understanding degree from the consumers who can obtain information increases from only a half (55.3%) to nearly the whole (90.8%).

TABLE 1 THE RESULTS OF INFORMATION DIFFUSION

	Times of Iteration	Total Amount of Information (Bit)	Number of Consumers Who Accept Information	Average Amount of Information (Bit)	Understanding Degree
$\omega=0.8$	18	1074.0	89	12.07	90.8%
$\omega=0.7$	17	899.5	86	10.46	78.7%
$\omega=0.6$	16	603.5	70	8.62	64.9%
$\omega=0.5$	15	286.6	39	7.35	55.3%

### Discussion and Analysis

Fig. 1 and Fig. 2 show that the amount of information in social network changes in an S curve which coincides with the S curves in other diffusion models. So this method can describe the information diffusion process between consumers.

With the increase of the accepting degree, the number of consumers who accept information increases, and the average amount of information increases. Especially when  $\omega$  changes between 0.5 and 0.6, the number of consumers increases fastest which increases from 39 to 70. When  $\omega < 0.5$ , the spreading speed attenuates fast, and the consumers who are far away from the information source have difficulty in accepting information. When the average accepting degree is more than 0.7, the effect of information spreading is better, and the proportion of consumers who can obtain information is 86 percent.

The experimental result shows that the ability of accepting information, the comparability of information, the intimacy of interpersonal relationship and the influence strength will affect the effect of information diffusion. Industries can realize the information transfer with a little wastage by improving the consumers' information accepting ability. In order to increase the field force between consumers, industries can publicize by advertisement, improve the understanding degree by providing the service of free trial. It is easier to spread information in the whole social network by publicizing product to the individuals whose interpersonal relationship is tight.

### The Effect To The Purchase Decision From Information Diffusion

The process of information spreading includes both the diffusion of positive information and negative information. The diffusion of positive information will promote consumers to make purchase decisions. And the diffusion of negative information will restrain

consumers to make purchasing decisions. Industries need to publicize product to consumers by the mass media and oral communication. First, industries spread information to a part of consumers by the mass media. Then these consumers can transfer this information to others. The information which is obtained by oral communication sometimes has a higher credibility, and will influence the decision more. Therefore, there is a critical impact on consumers' final decision by obtaining information through the bidirectional interpersonal relationships directly.

Fig. 1 and Fig. 2 show that when the diffusion steps are same, along with the increase of  $\omega$ , namely with the increase of average accepting degree to the information, the amount of information and the number of the consumers who accepting information are both increasing. According to the life cycle theory, with the increase of diffusion steps, the three stages during the process of information diffusion are the introduction stage ( $0 < \text{diffusion steps} < 5$ ), the growth stage ( $5 < \text{diffusion steps} < 10$ ) and the maturity stage ( $10 < \text{diffusion steps} < 20$ ). Combined with the consumer decision theory, during the introduction stage, the increment speed of the amount of information and the number of consumers who are accepting information is slow. So the introduction stage means the confirmation period in the process of making decisions. During the growth stage, the speed of the amount of information and the number of consumers who are accepting information is very fast. So the growth stage means the information search period in the process of making decisions with a great efficiency of information spreading. During the maturity stage, the speed of the amount of information and the number of consumers who are accepting information is close to zero. The consumers in destination have already completed gathering information, and have started to evaluate the scheme to make the final purchase decisions.

Therefore, the process of information diffusion influences the purchase decision greatly. During the confirmation period, industries should pay attention to publicizing product in the unidirectional interpersonal relationship network through advertisement, celebrities and other ways to guide the consumers to identify problems and to stimulate consumers to produce purchase motivation. During the information search period, the way of publicizing product need to be modulated to word-of-mouth publicity. Industries should focus on promoting the

consumer internal oral communication by providing chances of free trial. In this way, the product can obtain a better public praise in the bidirectional social network, and the consumers can obtain lots of credible positive information. It is helpful for the industries to spread the information about product with a higher quality and efficiency. And it is helpful to promote consumers to make decisions which are hoped by industries.

## Conclusions

In this paper, we introduce the theory of "field" in physics to construct an information diffusion field, and describe the network environment in which the information diffuses with the interpersonal relationship between consumers. Based on the analysis of the information diffusion field, we solve two problems of information diffusion: the condition in which information diffusion can occur is that there are connections between the two sides of consumers in the interpersonal relationships and there is information potential difference in a certain range; the rule of information diffusion is that the information spreads along the direction of the biggest gravity and the smallest gradient. On this basis, we study the process of information diffusion and have tests. According to the analysis of the results, we can draw the conclusion: information diffusion field can describe the information diffusion process between consumers, and the improvement of acceptance level can improve the efficiency of information diffusion.

Using the "field" theory to study the information diffusion process between consumers is of great significance to the information diffusion theory. By transforming qualitative analysis and empirical analysis into quantitative analysis, this paper provides some enlightenments and suggestions for industries to realize the diffusion of information about product. As we ascertain many variables by the method of random assignment during the experiment, the experimental result is a little random. So the experimental result can't reflect the specific impact on the diffusion by

various factors. However, through the simulation of adjusting variable, we have got some meaningful conclusions and the next research direction.

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## REFERENCES

- Ajay Agrawal, Devesh Kapur, John McHale. "How do spatial and social proximity influence knowledge flows? Evidence from patent data." *Journal of Urban Economics*, vol. 64, 258-269, 2008.
- Deng Yirui. "The research about information diffusion based on the theory of field." *Journal of intelligence*, vol. 8, 31-34, 2008.
- Guo Jiang, Zhang Li. "The application of Knowledge diffusion field in the city." *Industrial engineering and management*, Vol. 6, 89-95, 2005.
- Harte J.M, Koele P. A. "Modeling and describing human judgment processes: the multi-attribute evaluation case." *Thinking and Reasoning*, vol. 7, 29-49, 2001.
- J.A.Rex. "The sociology of a zone of transition, Reading in Urban Sociology." Oxford: Pergamon Press, 211-231, 1968.
- Li Zhang, Lan Jun. "The construction, analysis and application of Knowledge diffusion field." *Journal of Management Sciences*, vol. 18, 21-26, 2005.
- Lu Guoxian. "Special Issue: Migrant Workers in The Course of Urbanization." *Social Sciences in China*. vol. 3, 172-186, 2008.
- Wu Yangke, Lin Yingxing. "A research review of technology diffusion model." *Science and technology management research*, vol. 6, 397-399, 2009.